WHERE’S YOUR MASK? DISTANCE PERCEPTION IN MASK-WEARING

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Abstract

This study centered on the role that psychological resources (affected by fear and anxiety) play in distance perception. Utilizing a novel, virtual approach, participants were asked to judge the distance of a series of virtual, cartoon characters in two experiments. The first experiment asked participants to judge distance when the characters were depicted as either wearing or not wearing a mask. Participants were also asked to make these judgments in a second experiment under conditions in which the virtual character being depicted was identified as either someone familiar (friend) or unfamiliar (stranger). Participants also completed a demographic questionnaire and a Likert-style measure assessing their level of fear during conditions present in the coronavirus pandemic. Results of the study indicate that mask-wearing does influence participant distance estimates. Participants underestimated the distance of virtual characters in both experiments when the character was depicted as not wearing a mask. Familiarity did not significantly influence distance perception. These findings extend previous research that supports the role of fear in changes in perception, such as making objects appear closer (Cole, Balcetis, & Dunning, 2013), bigger (Vasey et al., 2012), and to move faster (Witt & Sugovic, 2012) when participants are exposed to fear-inducing stimuli. Continued research in this field may have clinical importance as identifying factors that affect safety-distance perception may allow for better planning and awareness in the instance of other pandemic or mass disease events. Additional research should also be conducted to extend these findings to other populations.

Keywords: Size and distance estimation; Action-specific theory of perception; Coronavirus pandemic; Mask-wearing.

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Introduction

A recent theory of how individuals perceive the environment is called the action-specific theory of perception (Gibson, 1979; Bhalla & Proffitt, 1999). Comprised of three elements – a visually specified environment, the body, and a purpose – this theory is based on the concept that individuals perceive the world in terms of their ability to perform an action in it (Proffitt, 2006). The basis of this theory is rooted in Gibson's (1979) ecological approach to perception, which names the primary objects of perception as affordances. Affordances are thus described as any possibility for action (Gibson, 1979). The current stance of the action-specific theory of perception agrees with Gibson's view that perception involves processes that are put into terms of an individual's potential to act. Therefore, similar environments will look different to individuals depending on their abilities. Thus, the current standpoint of the action theory of perception focuses on the influence that affordances have on perception (Witt & Riley, 2014). For example, a tall wall may be a barrier to older adults, but individuals who have skills in jumping over large obstacles, such as in parkour or gymnastics, may consider this to be an affordance. Consequently, an individual's perception is fluid and malleable throughout the course of one's life (Gibson, 1979).

Early research involving the action-specific theory of perception focused on terrain slant estimation as a means of perception (Proffitt et al., 1995; Kammann, 1967). Generally, this set of early studies found that slant perception is largely overestimated in humans (Proffitt et al., 1995, Witt & Proffitt, 2007). Proffitt et al. (1995) demonstrated this through a series of experiments using both haptic (tactile) and visual cues and found that humans perceive the incline of a hill to be steeper than it actually is. Participants were asked to give verbal feedback on the incline of the hill (visual), adjust the representation of a hill's cross section, and adjust a tilt board with their hand to match the perceived slope of the hill (haptic). Participants largely overestimated slant when asked using the verbal and cross sectional tasks, but not with the tactile measure. Participants judged a 5-degree hill to have a slant of 20 degrees and the slant of a 10-degree hill to be 30 degrees (Proffitt et al., 1995). Thus, given the absence of this overestimation in the tactile condition, it was concluded that there is a gross overestimation in explicit visual awareness, but action is accommodated to the actual properties of the environment (Proffitt et al., 1995).

Bhalla & Proffit's (1999) study on slant perception further adds to the theory of action-specific perception by tying in affordances to slant perception using physical capabilities of participants. This study examined slant perception when participant physiological abilities were challenged. To do so, Bhalla and Proffitt asked participants to wear a heavy backpack when judging the slope of a hill. Those who had lower physical capabilities (encumbered by wearing the backpack) perceived the hill to be steeper than those whose physical capabilities were higher (not wearing the backpack; Bhalla & Proffitt, 1999). Other research in this area has suggested that this mechanism serves as a potentially ecologically adaptive function, as humans operate via two distinct visual systems – one guiding immediate action (visuomotor) and the other planning for the future (explicit awareness; Witt & Proffitt, 2007). Thus, one's body uses overestimation of slant to better plan for the body's energy regulation (if you are burdened by a heavy backpack, it is ecologically adaptive to perceive a hill as steeper, so you are less likely to start climbing it and more likely to keep precious energy).

After conducting these studies on slant perception and looking into physiological factors of perception, researchers shifted to studying distance perception in relation to affordances. Distance perception refers to the process in which a person perceives an interval between two points in space (Witt & Proffitt, 2012). This avenue of the theory is based on George Berkley's account of visual depth perception, which noted that this perception must be added to by tactile sensations and eye convergence (i.e., the movement of eyes inward when focusing on an object; Proffitt et al., 2003). Researchers studying this avenue of the theory utilized studies in both physical and virtual environments. Proffitt et al. (2003) developed a series of three experiments to assess the role of physiological manipulations on distance perception. During these experiments, Bhalla and Proffitt examined the effect of wearing a heavy backpack in a physical environment compared to a virtual environment. The first experiment involved having participants wear a heavy backpack, traverse a particular distance, and guess the length of the distance after they traversed it. Participants who wore a backpack demonstrated larger distance estimates than the control group who did not wear a backpack (Proffitt et al., 2003). The following experiments were carried out in a virtual setting using a head mounted display (HMD) and a treadmill. These experiments assessed the effect of optic flow (i.e., apparent movement of objects in a visual scene caused by the relative motion between an observer and the scene; Anstis et al., 1998) on visual-motor aftereffect (i.e., an illusion of motion caused by prior exposure to movement in the opposite direction; Anstis et al., 1998). Participants were placed on a treadmill and exposed to a virtual scene that was either moving or stationary. Participants were then asked to judge distance. The results demonstrated that manipulating the absence or presence of optic flow while participants walked on a treadmill influenced their calibration between forward walking effort and anticipated optic flow. In other words, after walking on a treadmill without optic flow, blindfolded participants walked forward when attempting to walk in place. This was seen in the third experiment in the series, which found that those who had experienced no optic flow estimated distances to be farther than those who experienced flow (Proffitt et al., 2003). Thus, it was demonstrated that anticipated physiological effort influenced perceived distance.

Other research has also demonstrated that as effort related to action increases, so does perceived distance. Witt, Proffitt, and Epstein (2004) demonstrated that reachability also affects participant distance estimates. Even if at the same actual distance, participants perceived targets that were beyond reach as farther than those within reach. This was determined by having participants reach for an object while holding a tool and then reaching for the same object using only their arm. When participants used the tool to reach for the targets just beyond arm's reach, the targets appeared closer than when they reached without the tool. This was also demonstrated when individuals were asked to throw a heavy ball compared to a light ball (Witt et al., 2004). Participants judged distances to be farther when the effort to carry out these acts was greater. Together, this research demonstrates that individuals imaging performing an action can influence perception and the perceived outcome of the action.

Throughout the literature on the action specific theory of perception, several types of resources have been identified to be able to influence an individual's potential for action. These include physiological resources (e.g., age, energy level, physical ability), performance/expertise/skills, and psychological resources (e.g., stress and fear). Several examples of physiological influences have been mentioned previously, such as the presence of a heavy backpack (Proffitt et al., 2003) and age (Gibson, 1979). Several other studies have demonstrated the effects of physiological factors on potential for action such as glucose consumption and depletion (Schnall et al., 2010; Taylor-Covill & Eves, 2013, 2014, 2016). Research on glucose consumption has demonstrated that participants perceived their environment in greater terms of their ability to act when they had recently consumed a sugary drink. In other words, participants who consumed a sugary drink perceived a slanted environment to be shallower than those who had not consumed an energy drink (Schnall et al., 2010). Low blood-sugar level is considered to encumber the body, just as other physiological factors such as age, fatigue, and declining health (Proffitt et al., 1995; Bhalla & Proffitt, 1999). These resources can lead an individual to perceive hills as more or less steep (Schnall et al., 2010; Proffitt et al., 1995; Bhalla & Proffitt, 1999) and objects as more or less distant (Bhalla & Proffitt, 2003; Witt et al., 2005).

Much of the research that has been conducted on the action-specific theory of perception has focused on the influence that performance/expertise in a task or sport has on one's perception of the environment. Several influential studies within the theory have identified that sport players who report performing well also perceive their targets to be bigger. For example, softball players who are performing well often perceive the ball to be bigger (Witt & Proffitt, 2005), tennis players often perceive the ball to be moving slower (Witt & Sugovic, 2012), and golf players endorse statements of the hole appearing bigger on the green (Witt & Proffitt, 2012). The procedures used in these studies are similar and generally involve athletes reporting their game statistics and picking the size of their target from a series of photographs or measurements. For example, Witt and Proffitt (2005) recruited their participants by setting up a booth at a local softball field. As athletes walked by, they asked if they would choose the size of a softball from a series of eight circles. After the athletes chose, they were also asked to report their game statistics (e.g., number of times at bat, number of hits and walks, and how many times they got on base because of an error). The study found that those who reported higher levels of hitting success also reported larger perceived softball sizes. These studies all support the framework that one's ability to act influences the appearance of a goal.

In addition to physiological and performance-based factors influencing an individual's potential to act and their perception, there are several psychological factors that influence this as well. More specifically, fear and stress responses can be influential. In these studies, stress and fear are largely connected as those who experience fear also tend to experience stress responses (Steimer, 2002). Some research has noted the role of stress in performance, such as the occurrence of "choking" (i.e., a detrimental effect on performance; Oudejans & Pijpers, 2009). The literature has become increasingly focused on the role of stress on perception, noting that anxiety has an effect on perception specifically (Nieuwenhuys et al., 2008). This has been demonstrated in studies conducted by Stefanucci and colleagues (2008), which found steeper hill estimates from participants who felt more anxious when standing on top of a hill (either on a skateboard or on a box of the same height) compared to those who experienced lower levels of anxiety. Further, Stefanucci and Storbeck (2009) expanded on this study by demonstrating that even emotional arousal influences height perception. This was measured by comparing participant distance scores from a balcony to the ground below after either viewing an arousing picture or not. Those who viewed the arousing photo prior to giving their distance estimate overestimated compared to participants who did not view the photo prior to estimating the distance. Generally, studies examining the role of fear in perception have identified that experiences of this emotional state lead to changes in distance perception. It is crucial to further understand the effect that this state has on perception.

Effect of Fear on Perception

Generally, fear has been found to influence perception. More specifically, it has been established that those who experience extreme fears also experience increased perceptual distortions (Rachman & Cuk, 1992). Much of fear's influence is rooted in the concept of affordances, which has been previously described as any possibility for action (Gibson, 1979). In general, humans do a very good job of determining their affordances and can adjust sufficiently to changes in their environment or body (Proffitt & Linkenauger, in press), but this capability can be influenced by emotional changes associated with the body, such as the experience of anxiety or fear (Greydon et al., 2012). These psychological/physiological changes can cause an individual to initiate withdrawal behaviors in an attempt to avoid potentially threatening situations. This allows for changes in one's perception of his surroundings to occur (Stefanucci et al., 2008).

Greydon and colleagues (2012) conducted a study examining changes to an individual's perception of affordances when encountering an anxious state. Participants underwent three experiments, each manipulating anxiety levels and personal capabilities. The first experiment examined participant reachability when exposed to anxiety (induced by restricted breathing through a small straw). Participants underestimated their reachability when in an anxious state compared to when in a calm state. The second experiment utilized the same anxiety exercise as the first study, but researchers were interested in anxiety's effect on participant's perceived grasping capabilities. Results were consistent with previous findings demonstrating that individuals underestimated their capabilities when in an anxious state compared to a calm state. The third experiment tested participants' perceived passability of their hand through an aperture. Participants underwent the same anxiety-inducing breathing procedure as in the previous studies and were asked to judge the extent to which their hand would fit through a series of different-sized holes. Findings for this study remained consistent, indicating that perceived judgements of passability were more conservative when in an anxious state compared to a calm state. Generally, these findings suggested that individuals became more conservative of the judgements of their action capabilities when experiencing an anxious state, including reachability distance, grasping capability, and fitting ability. In other words, individuals tended to underestimate or perceive their potential to act as being lower when in a state of anxiety. These same results have also been found in experiments surveying climbers' movements and speed. These studies noted shorter and less accurate movements as well as an increase in the amount of time to make these movements in anxious climbers compared to climbers in a non-anxious state (Pijpers et al., 2005; Pijpers et al., 2006). Further, these changes were found to be influenced by the underlying fear of the consequence of making a wrong move.

Additional research examining the role of fear in perception has largely focused on its influence in conjunction with phobias and extreme fears. Several studies involving heights have found that in participants who have a fear of heights, higher distance estimates to the ground were given compared to those who were not afraid (Clerkin et al., 2008; Stefanucci & Proffitt, 2009). Clerkin and colleagues (2008) assessed this by conducting an experiment in which participants were asked to estimate the distance of two balconies to the ground. Before estimating the distance of one of the balconies (this was counterbalanced), participants engaged in an imagery exercise designed to enhance the subjective sense that they were acting in a dangerous environment by picturing themselves falling. Stefanucci and Proffit (2009) assessed this by conducting an experiment in which height perception was determined both looking up (from the bottom) and looking down (from the top) of a balcony. Participants were asked to complete an acrophobia (e.g. fear of heights) measure before giving distance estimates by standing at the base of a building and on top of a balcony (8 meters from the ground). Participants largely overestimated height (by 60%) when standing on the balcony compared to when looking up at the balcony from the ground (30%). These perceptual distortions increased with higher acrophobia scores.

Increased distance perceptions were also seen in slant perception studies, where participants who were put in a threatening situation overestimated the slant of the hill more so than those who were presented with a non-threatening situation (Stefanucci et al., 2008). As mentioned previously, participants in Stefanucci et al.'s (2008) study were assigned to a condition in which they stood on the top of a hill on either a skateboard or a wooden box of the same height. They were instructed to give three estimates of slant: a verbal report, a visually matched estimate, and a visually guided action. Participants who reported fearful reactions to the threatening condition (standing on the skateboard) consciously judged the hill to be steeper than unafraid participants. This visually guided action measure was the same across trials. This suggests that explicit awareness of slant is influenced by the fear associated with potentially dangerous actions (i.e., skateboarding) that could be performed on the hill.

Additionally, individuals tend to alter their perception of negatively arousing objects and situations (Easterbrook, 1959). For example, studies involving other phobias, such as a fear of spiders, have found that threatening objects often appear bigger (Vasey et al., 2012; Matthews & Mackintosh, 2004), closer (Cole et al., 2013), and in some cases faster (Witt & Sugovic, 2012) than non-threatening or neutral objects. Vasey and colleagues (2012) conducted a study in which participants with a fear of spiders (e.g., arachnophobia) were exposed to tarantulas of varying sizes (1 to 6 inches) and asked to estimate their size after each exposure. Those who reported having a higher fear of spiders (measured by a verbal report on a scale of 1 to 100), also reported larger size perceptions of the spiders. These perceptual distortions increased as participant's level of fear increased. More generally, studies assessing these size changes have identified that as fear of a certain object or situation increases, so does the inaccuracy of the perception. This is due to the idea that threat influences perceptions because it calls for immediate action or preparation for action (Cole et al., 2013). Together, this suggests that fear leads to perceptual distortions of variables such as size and distance across many different fear-inducing settings.

Familiarity

Perception research based on the impact of familiarity suggests that people perceive others as being closer to them the more that they know or are familiar with them (Matthews & Matlock, 2011; Vestner et al., 2019) or in some cases, promote a feeling of safety (such as wearing a mask during a pandemic; Cartaud et al., 2020). In fact, many studies have suggested that social support can be quite beneficial due to its “buffering” effect, such that it can alleviate proximal stressors (e.g., reducing cardiac stress reactions to arithmetic when accompanied by a friend; Kamarck et al., 1990), reduce cardiac reactivity when performing a stressful task when accompanied by a pet (Allen et al., 1991), and promote health (e.g., helping to prevent the onset of stress-related illnesses; Seeman & Syme, 1987). Conversely, the saying, “keep your friends close and your enemies closer” has also been found to be taken much more literally in perception literature. When adding fear and the perception of threat into the equation, those who are considered to belong to the out-group (whether that be a result of not knowing the person or not being friends with them) are perceived as being closer than those who are a part of the in-group (Xiao & Bavel, 2012). Xiao and Bavel (2012) demonstrated this concept through a series of studies. The first study examined New York Yankee fans and non-Yankee fans in regard to distance perception of a threatening target (Fenway Park, home of the Red Sox and rival of the Yankees) compared to a neutral target (Camden Yard, home of the Orioles). Those who estimated the location of the Red Sox stadium to be closer were a part of the in-group (Yankee fans) compared to the out group (non-Yankee fans), who did not estimate the distance of the "threatening" target to be closer. Thus, when an individual belongs to an "in-group" or, a group that one is familiar with (Yankee fans), that of which belongs to the "out-group," whether it be individuals or objects (such as Fenway Park), are perceived as being closer as they pose a threat to these individuals.

This same experiment was conducted in two other settings by the same researchers. The first experiment examined the role of in-group vs out-group membership in relation to university settings. Participants were students and staff from New York University (NYU) and were presented with one of two articles from a US newspaper, one portraying a New York University (Columbia) as a superior rival to NYU (threat condition) and the other portraying the same university in an equal positive regard to NYU (control condition). Participants were then asked to give a distance estimate between NYU and Columbia. Those who were considered to be a part of the "in-group" (i.e., NYU students) perceived Columbia to be physically closer when asked to read the article portraying Columbia as a rival than those who were asked to read the article that portrayed the universities in the same positive regard (Xiao & Bavel, 2012).

The final experiment assessing the role of group membership on perceived distance examined the threat of Mexican immigration on Americans living in New York. Xiao & Bavel (2012) asked participants to first complete a 4-item modified version of the Perceived Realistic Threat Scale (Stephan et al., 1999). This scale assessed the degree that American participants agreed or disagreed with statements relating to the burden that Mexican immigration posed (e.g., "Immigration from Mexico is undermining American culture"). Participants were then asked to estimate the distance from New York City to Mexico City, Mexico City to Los Angeles, and Mexico City to Vancouver, Canada. The distance estimation between New York and Mexico

City was used as the “threatening” domestic city, whereas Los Angeles and Vancouver were used as “non-threatening” control cities (one domestic and one foreign). The results demonstrated that subjective feelings of threat from Mexican immigration predicted perceived distance, such that higher threat perception correlated with closer distance estimates (Xiao & Bavel, 2012).

These three studies demonstrate the role that group membership plays in perceived distance estimates. When presented with stimuli depicting something belonging to an “out-group,” individuals who belong to the “in-group” are more likely to view these stimuli as being closer simply because it is perceived as being a threat to their own group membership. In terms of the pandemic, this group membership dynamic could be demonstrated among friends (who are more trusted and are less threatening) and strangers (who are less trusted and are more threatening).

Proxemics

It is well known that individuals often have negative reactions to their personal space being invaded (McCall, 2016; Khan & Kamal, 2009). Research within this area has also noted that this reaction can be amplified in accordance with one’s affective states and cognitive responses (McCall, 2016). In fact, much of human satisfaction within this context relies on how free an individual is to be in control of their spatial environment (Philip, 2001). The study of how space is used within the context of human interaction is referred to as proxemics (Haddad et al., 2019), and can be broken up into four “zones.” These zones are intimate (e.g., that of which involves direct contact), personal (e.g., ranging from 1 to 4 feet), social (e.g., ranging from 4 to 12 feet), and public (e.g., ranging from 12 to 25 feet or more; Haddad et al., 2019). Within the context of these zones, non-verbal forms of communication are associated, and invasion of these zones can lead to a variety of consequences when violated (i.e., being viewed as being intimidating or disrespectful). These consequences are housed within the compensation, balance, and privacy theory of proxemics, which states that people constantly adjust their use of space to fit the presence and interaction with others (McCall, 2016). Research on this theory has identified that humans tend to move closer to objects that they are interested in and stand distant relative to others depending on tasks at hand (Marquardt & Greenberg, 2015). Research in personal space invasion has demonstrated that objects that are within a person's immediate space are perceived as being closer when they belong to another person than when it is an object owned by the individual (Schnall et al., 2005). This mechanism may also be applied to situations in which threatening objects are perceived as closer (Shankman & Klein, 2003; Stefanucci et al., 2008), such as in the Coronavirus pandemic, in which invasions of personal space have potentially life-threatening consequences. When applied to the pandemic, individuals may perceive "outside" objects as being closer or bigger than they actually are (e.g., a person coughing may be encoded as an invasion of one's personal space, and therefore be judged as closer or bigger).

There are limited studies that assess distance perception in terms of proxemics, but a few studies have noted that invasions of personal space can evoke feelings of discomfort and withdrawal behaviors (Sundstrom & Altman, 1976; Vine, 1982). Previous research on withdrawal behaviors has noted that this reaction can lead to more conservative perception judgements from individuals, such as perceiving one's distance from a distressing object as closer than one would normally perceive it to be if it did not have a negative emotional reaction tied to it (Shankman & Klein, 2003; Stefanucci et al., 2008). During the coronavirus pandemic, individuals are advised to stay at least 6 feet apart when in public spaces. When this boundary is broken, individuals may interpret that as an invasion of their personal space, leading to the experience of discomfort. This discomfort may trigger an individual to increase the distance between themselves and the other person. A more conservative judgement of distance may then occur, leading to a more conservative space (i.e., a distance greater than the 6 feet) to be created. Together, this suggests that personal space plays a crucial role in perception and may be influenced by factors related to the pandemic (i.e., mask wearing).

The Current Study

Several studies have addressed the role of fear in perception, specifically when taking into account factors such as familiarity and approximation (McCall, 2016; Xiao & Bavel, 2012). During the Coronavirus pandemic, much attention has been given to physical distance measurements, such as instructing individuals to stay 6 feet apart. Tied to the pandemic, safety concerns have risen and created a sense of anxiety in those who are concerned about contracting the disease. Many of these individuals may experience anxiety around others in both private and public places (CDC, 2020). Given the research relating to strangers and the perception of threat, it is plausible to think in terms of these same mechanisms and apply them to the pandemic. The introduction of masks has aimed to decrease this anxiety and improve the safety of others while in public spaces, but research has not tested whether masks will impact distance perception of individuals.

The current study tested distance perception using images of virtual characters presented on a desktop computer or mobile phone. Specifically, the effect of mask wearing and familiarity on distance estimation was addressed. Based on the literature reviewed previously, the action-specific theory of perception, and the mechanisms that have been described related to fear perception, the current study hypothesized that, during the pandemic, when judging the distance of an individual: 1) a person depicted as not wearing a mask would be perceived as closer than someone depicted as wearing a mask; 2) strangers would be perceived as being closer than someone who was familiar.

Method

Participants

Two hundred and forty-three participants were recruited to participate in the study through social media platforms (Reddit, Facebook, and Instagram). Participants were excluded if they did not consent to participate in the study, endorsed a perceptual disorder, or were not at least 18 years of age. Only participants who completed the study in full (n = 74) were included in the data analysis. The total number of participants that was estimated for a 2x2 within-subjects ANOVA in this experiment was 54 to achieve a medium effect size of .25; this would generate a statistical power of .95 (α = .05; G*Power, 2019). Out of the 74 participants that completed the study, 66 were female (89.2%), 7 were male (9.5%), and 1 (1.3%) preferred not to answer. Participants who completed this study were between 21 and 72 years old (M = 36.96 years, SD = 12.97 years), and were primarily Caucasian (n = 67, 90.5%). Education levels of participants varied widely, with most participants having completed a bachelor's degree (n = 25; 33.8%). 21.6% of participants cited completing an associate degree (n = 16), followed by 18% (n = 14) citing some college education and 12.5% (n = 10) a master's degree. A small number of participants completed a Ph.D. or higher (5.4%, n = 4), while the remaining participants cited completing either a high school (n = 2, 2.7%) or trade school (n = 2, 2.7%) education. Only one participant endorsed only completing some high school (1.4%).

Materials

Qualtrics, an online survey platform, was used to administer the study. The study consisted of three parts: consent, two experimental conditions (Appendix A), and a series of follow-up questions on fear ratings and demographic information (Appendix B). The study assessed the effects of mask wearing and familiarity on perceived distance perception.

Stimuli

Three sets of virtual characters (referred to as Joe, Fred, and Clyde) were used in the experiments. These characters were depicted as either wearing or not wearing a mask. Each character was presented on a screen and appeared at 5 distances, ranging from 4 feet to 8 feet. Distances varied in 1-foot increments. Each character was presented on a plain white background with the outline of a “room” in which they were standing. “Joe” was presented as a Caucasian male with blonde hair and wearing a blue shirt. “Fred” was presented as a Caucasian male with black hair and wearing a red shirt. “Clyde” was presented as a Caucasian male with brown hair and a green shirt (see Appendix A). Character names were picked, checking with previous literature to ensure that they did not have a history of negative connotations associated with them.

Experiment 1: Mask Factor. This experiment was a two-level within-subject design. It manipulated only one factor (mask wearing) with two levels (virtual character wearing a mask vs not wearing a mask). This experiment used Joe as the virtual character and consisted of 30 trials. Joe was depicted as wearing a mask in half (15) of the trials and not wearing a mask in the other half (15); these were presented in random order, differing in order for each participant. The distance of Joe also varied per trial. Joe was depicted at each of the 5 distances (increments of 1-foot from 4 feet to 8 feet) when he was both wearing and not wearing a mask. Joe appeared three times for each condition (distance x mask). Thus, Joe was depicted in each of the distance increments six times, three when wearing a mask and three when not wearing a mask. The order of distance presentation was randomized, with a different order for each participant. Each slide showed the character at an estimated distance, with a multiple-choice option for participants to choose the corresponding size. At the beginning of the trial block, a slide with text appeared. This slide instructed participants to study the distances present on the next image (Appendix C). Once participants read the instructions, participants were presented with a new screen depicting the possible distances of the virtual characters (Appendix A). Once participants studied the distances, they were asked to continue to the experimental task.

Experiment 2: Mask and Familiarity Factors. This experiment utilized a 2 (mask wearing) x 2 (familiarity) within-subject factorial design. Each factor consisted of two levels, with the mask variable consisting of masks being present or absent and the familiarity variable consisting of whether a character was depicted as a friend or stranger. This experiment used Fred and Clyde as the virtual characters (different characters from Experiment 1). Fred was used to depict a character who was a “friend” and Clyde was used to depict a character that was a “stranger.” This experiment involved 60 trials. The trials were split into two blocks, consisting of 30 trials each. These blocks separated the levels of the familiarity condition; thus, one block consisted of 30 “friend” trials and the other block consisted of 30 “stranger” trials. The order of these blocks (first friend and then stranger, or vice versa) were counterbalanced across participants. At the beginning of each block, a slide with text appeared. The slide instructed participants to study the distances presented on the next image (Appendix C). Once participants read the instructions, participants were presented with a new slide depicting the possible distances of the virtual characters (Appendix A). Once participants studied the distances, they were asked to continue to the experimental task. Participants were given either a scenario describing a “friend” (e.g., “You are walking in the park and stop to watch a squirrel eat a nut. A person approaches you, and when you look up, you see it is your friend Fred. You stop to talk with Fred, and he informs you that he recently received a promotion. You congratulate him and agree to celebrate with dinner and drinks later that day.”) or a “stranger” (e.g., “You are walking to your car and notice someone is getting out of the car parked next to you. He seems to be in a rush and slams his door loudly, making you jump. You do not recognize this person.”). Following this slide, the trials began. For each trial, a slide appeared with the chosen character (Fred if the “friend” block of trials was first or Clyde if the “stranger” block was first) and participants were asked to indicate the corresponding distance of the virtual character (the same experimental task from the first experiment). The character was shown as either wearing a mask or not wearing a mask. In each block, the character was depicted as wearing a mask for half of the trials (15) and for half of the trials (15) he was not. This was presented in random order, different for each participant. Fred and Clyde were also depicted at each of the distance increments (1-foot increments from 4 ft to 8 ft) six times, three times for each masked condition and three times at each distance (Appendix A). The order of size presentation was randomized, with a different order for each participant.

Follow Up. This portion of the study consisted of seven Likert-style questions and four demographic questions. These questions were created to further assess the factor of fear in relation to participant performance in both experiments. Six questions assessed participant levels of comfort in regard to mask wearing and one question assessed the participant fear levels in relation to coronavirus. Participant responses were based on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Participants were asked to rate the level that they agreed with each of the following statements:

1) “I feel comfortable being close to an individual in public during the coronavirus pandemic.”

2) “I feel comfortable being close to an individual in public without a mask during the coronavirus pandemic.”

3) “I feel comfortable being close to an individual in public with a mask during the coronavirus pandemic.”

4) “I feel comfortable being in public without a mask.”

5) “I feel comfortable being in public with a mask.”

6) “I am fearful of the coronavirus and the coronavirus pandemic.”

7) “I am not fearful of the coronavirus and the coronavirus pandemic.”

Next, participants were asked to give their age, gender, ethnicity, and education level. Questions on gender, ethnicity, and education were given an option to enter any response not originally included in the choice options (Appendix B).

Procedure

Participants accessed the link to the Qualtrics survey via social media site postings. After accessing the study, participants were directed to a consent page where they were informed about the details of the study. Participants were informed that they would not be able to participate if they were under the age of 18 or had any known visual or perceptual impairments. If the participants endorsed any of the exclusionary criteria or did not agree to participate in the study, they were directed to the end of the study and thanked for their time. If participants did not endorse any of the exclusionary criteria and agreed to participate, they were directed to their first experimental task.

In Experiment 1, participants were asked to complete 30 trials (one slide per trial). In each slide, participants were asked to match the apparent distance of a virtual character with one silhouette of the same size that they were asked to study at the beginning of the experiment block. In each slide, the character varied in respect to distance (5 different distances of the character) and mask presence or absence. A different, random sequence was used for each participant. In each slide, along with a virtual character, 5 multiple choice option were present for the participant to choose from (Appendix A). Participants were asked to pick the distance that corresponded to the virtual character on that slide. Participants were given 10 seconds to complete each trial. Following each selection, a new trial began, and participants were asked to complete the same procedure, but with a different variation of the image. This continued until the 30 trials were completed. This took approximately five minutes to complete.

After completion of the first experiment, participants were directed to the second experiment. In the second experiment, participants were asked to complete two blocks of 30 trials each. Participants were asked to read a short scenario for each block and then complete the same distance matching activity from the first experiment. The participants were given a block depicting a virtual character as a “friend” (Fred was the character) and another block as a “stranger” (Clyde was the character), in counterbalanced order across participants. At the beginning of each block, participants were first shown a slide in which a brief scenario was described. This scenario was shown on the participant’s screen until they clicked to the main task. After reading the scenario, 30 trials were presented for each block. The procedure for each block were identical to that of Experiment 1. This experiment took approximately 10 minutes to complete.

After participants completed the two experiments, they were directed to a follow-up questionnaire. Participants were asked to provide information on their gender, race, and level of education. They were also asked to complete seven Likert-style measures. Demographic questions were asked first, followed by the Likert-style measures. After completing the follow-up questions, the participants were directed to the end of the survey and thanked for their time. The entire experimental session lasted approximately 15 minutes.

Scoring

Main Analyses. Participants were shown one virtual character per slide/trial and asked to indicate the matching distance from 5 distance estimates. Participants chose the corresponding distance from a list of multiple-choice options (from 4 ft to 8 ft: 4 = smallest size (4 ft), 8 = largest (8ft)). For each trial, the score was determined according to whether there was no bias present in the participant's answer, an overestimation, or an underestimation in their response. Therefore, if the participant picked the correct distance of the virtual character (i.e., no perception bias was present), they received a score of zero. If the participant picked a distance further away than what was actually depicted (i.e., overestimation of distance), a positive score was given (e.g., 1, 2, or 3). If the participant picked a distance closer than what was actually depicted (i.e., underestimation of distance), a negative score was given (e.g., -1, -2, or -3). To allow for overestimation and underestimation of distance, only trials in which the virtual characters were present at 5 ft, 6 ft, and 7 ft distances were scored. Trials in which the virtual characters were depicted at 4 ft and 8 ft distances were given a score of 9 and were not included in the analyses.

Likert Measures. Participants were given seven Likert-style questions that assessed fear in relation to mask-wearing. Participants were asked to rate their agreeance with a series of statements on a scale of 1 (strongly disagree) to 5 (strongly agree). Questions 1 (*I feel comfortable being close to an individual in public during the coronavirus pandemic*), 2 (*I feel comfortable being close to an individual in public without a mask during the coronavirus pandemic*), 4 (*I feel comfortable being in public without a mask*), and 7 (*I am not fearful of the coronavirus and the coronavirus pandemic*) were reverse coded so higher scores indicated higher reports of fear. A total score was calculated for the measure using participant responses to obtain an overall measure of fear of the participants.

Results

Experiment 1: Mask versus No Mask

A paired-samples t-test was conducted to analyze whether there was an effect of mask presence (on a virtual character's face) on participant mean error distance estimates. A significant effect was found ($t(73) = 3.02$, $p = .003$; Cohen's $d = .351$). Participants underestimated the distances of non-masked virtual characters ($M = -0.11$, $SD = .51$) more often than they did masked characters ($M = -0.02$, $SD = .50$). This indicates that participants perceived the virtual characters to be closer when not wearing a mask than when they were wearing one (see Figure 1).

Experiment 2: Friend versus Stranger

A 2 (Mask vs No Mask) x 2 (Friend vs Stranger) within-subject ANOVA was conducted to examine the effect of mask presence/absence and familiarity on participant mean error distance estimates of a virtual character. A significant main effect of mask-wearing was found ($F(1,73) = 6.203$, $p = .015$, $\eta_p^2 = .078$). This suggests that the presence/absence of a mask did affect distance estimates of participants (see Figure 2). More specifically, participants tended to perceive virtual characters to be closer when not wearing a mask than when they were wearing one. Both the main effect of familiarity ($F(1,73) = .103$, $p = .749$, $\eta_p^2 = .001$) and the mask wearing by familiarity interaction ($F(1,73) = .893$, $p = .348$, $\eta_p^2 = .012$) were found to be non-significant.

Additional Analyses of Incomplete Data

In addition to the 74 participants that completed all 90 distance estimation trials, there were other participants (who were not included in the analyses above) that completed partial distance estimation trials (consisting of at least one completed trial per distance). Considering both participants with complete data and these participants with partial distance estimation trials, Experiment 1 had a total of 116 participants and Experiment 2 had a total of 87 participants. These data sets were subject to the same statistical analyses as above (i.e., paired samples t-test (Experiment 1) and within-subject ANOVA (Experiment 2)). The results of these analyses were consistent with the findings of the original analyses of the full data sets. A significant effect was found ($t(116) = 2.105$, $p = .037$; Cohen's $d = .195$) for Experiment 1. Participants underestimated the distance of a non-masked virtual characters ($M = -.11$, $SD = .52$) more often than they did masked characters ($M = -.05$, $SD = .53$). This indicates that participants underestimated the distance of a virtual character (they perceived the virtual characters to be closer) when a mask was not depicted on the character's face. A significant main effect of mask-wearing was also found when conducting a factorial within-subject ANOVA (Experiment 2; ($F(1,86) = 8.185$, $p = .005$, $\eta_p^2 = .087$)). The main effect of familiarity ($F(1,86) = .387$, $p = .535$, $\eta_p^2 = .004$) and the interaction effect ($F(1,86) = .106$, $p = .745$, $\eta_p^2 = .001$) were not significant. This suggests that, even when including participants who only completed one trial per distance, the sample still experienced the same effects on distance perception as the sample including only those who completed all of the trials.

Relationships Between Variables

Two reliability analyses were conducted on participant fear responses. The first analysis found the fear scale to be somewhat reliable (7 items; $\alpha = .67$). Item-total statistics indicated that deletion of the item, "I feel comfortable being close to an individual in public with a mask during the coronavirus pandemic" yielded a higher Cronbach's alpha of .84. Thus, this item was deleted and a total score (sum of all participant ratings for individual items) consisting of the remaining 6 items was calculated. This score was used in the correlation analyses with the main variable (participant mean distance error scores).

Several one sample t-tests were conducted to assess whether bias was present between mask and no mask conditions across experiments. Negative scores indicated viewing the virtual characters as physically closer and positive scores indicated viewing the virtual characters as physically further away. A sum of the mean error distance scores for both the masked conditions (across Experiments 1 and 2) and non-mask conditions (across Experiments 1 and 2) was computed. Respectively, one-sample *t*-tests were conducted to compare the summed mean error distance scores for masked trials and non-masked trials with a test value of zero (indicating no bias was present). It was found that virtual characters were not viewed differently when depicted with masks ($t(73) = .247$, $p = .806$, $d = .029$) or without masks ($t(73) = - 1.132$, $p = .261$, $d = -.132$).

Additionally, a total count was conducted to examine how many instances of bias (underestimation of distance, overestimation of distance, and no perceptual distance bias) was present in both masked and non-masked conditions in the study. Overall, participants largely reported no bias in their distance estimates (indicated by a trial score of zero) in both the masked ($n = 1127$) and non-masked ($n = 1128$) conditions. Participant overestimation scores in the masked condition were larger ($n = 449$) than those in the non-masked condition (n = 394), and participant underestimation scores in the masked condition were smaller ($n = 422$) than those in the masked condition ($n = 476$).

Utilizing the total count data, correlations were conducted for each of the bias conditions in relation to participant fear ratings. No significant correlations were found. Masked ($r(74) = .016$, $p = .893$) and non-masked ($r(74) = - .063$, $p = .593$) conditions in which participants indicated no bias during the trials (indicated by a score of zero) were non-significant. Additionally, no significant correlations were found between masked ($r(74) = .025$, $p = .831$) and non-masked ($r(74) = -.014$, $p = .906$) conditions in which participants overestimated the distance of the virtual characters during the experiments as well as between masked ($r(74) = -.036$, $p = .760$) and non-masked ($r(74) = .042$, $p = .720$) conditions in which participants underestimated the distance of the virtual characters.

Several additional correlations were conducted to examine associations between demographic variables (age, education) and single-item measures (fear ratings) with the main variables of interest (distance error scores for each experiment and experimental condition). Gender and ethnicity variables were not examined due to the disproportionate number of responses in each category. All of these relationships were found to be non-significant. Thus, fear was not found to be significantly correlated with distance error scores. The relationship between participant age and fear rating was found to be marginally significant ($r(74) = -.219$, p = .061), indicating a non-significant trend that as participant age decreased, perceived fear ratings increased (for a full list of correlations, see Table 1).

Discussion

Previous studies have addressed the role that fear (Clerkin et al., 2008), familiarity (Vestner et al., 2019), and proximity (Schnall et al., 2005) have on distance perception. Within these studies, objects or individuals that are feared or unfamiliar have been noted to be perceived inaccurately, such as being closer (Cole, Balcetis, & Dunning, 2013), bigger (Vasey et al., 2012), or faster (Witt & Sugovic, 2012) than they actually are. Previous literature in this area has lacked assessment of safety measures within this context, such as the use of masks to protect against disease. To address this, the current study examined the impact that mask wearing and familiarity have on distance perception.

According to the action-specific theory of perception, individuals perceive their environment in terms of their ability to act (Bhalla & Proffitt, 1999; Proffitt, 2006). This theory is based on a much broader concept of affordances, which is a defined as any ability to act (Gibson, 1979). Research within this area has identified various factors that can influence perception generally, such as physiological effort, performance, and psychological resources. The current study specifically addressed the role of psychological resources (affected by fear) on distance perception, specifically through the presence and absence of masks. The results indicate that the presence (and absence) of face masks does alter distance perception in individuals. Consistent with my hypothesis, participants perceived virtual characters to be closer when they were depicted as not wearing a mask than when they were wearing one.

The finding that face masks do alter distance perception can tie into previous studies examining the role of psychological resources on perception. Within this context, the most common factor that has been studied is fear. Past research has found that the feeling of fear can increase the occurrence of perceptual distortions, especially in individuals who endorse high levels of fear (Rachman & Cuk, 1992). Fear itself is associated with increased levels of anxiety and overall changes to the body, such as initiating withdrawal behaviors in an attempt to avoid threatening situations. A range of studies have addressed this, examining fear through the lens of personal capabilities (e.g.., reaching for an object), height fear studies, and phobias. Greydon and colleagues (2012) examined perceptual changes in reaching capabilities while in an anxious state. Their results indicate that individuals underestimated their abilities (both perceived and actual) when in an anxious state compared to a calm state. In the current study, the influence of fear was thought to influence perception when virtual characters were depicted as not wearing a mask, and calmer states were created when these characters were depicted as wearing one. Participants in the study displayed closer distance perceptions when in the “anxious” condition compared to the “calm.” This may suggest that the underestimation bias could also occur in other situations where fear-inducing situations is an influencing factor.

The results of this study can also tie into the research of Clerkin and colleagues (2008) and Stefanucci and Proffit (2009) who examined the role of height fear on perception. Participants were asked to give height estimates when standing below a balcony looking up and standing on a balcony looking down. This research also indicated perceptual distortions when in an anxious/fearful state. More specifically, participants indicated overestimated height responses (e.g., thought the balcony was higher from the ground) when in an increased fearful state (i.e., standing from the top of a balcony looking down) compared to a less fearful state (i.e., standing on the ground looking up at the balcony). Analogous findings were reported in a series of studies examining the role of arachnophobia on perception (Vasey et al., 2012; Matthews & Mackintosh, 2004). Participants underwent an experiment in which they were asked to give size estimations after being shown a series of spiders (all of different sizes). Participants who reported a higher fear of spiders also endorsed these animals to appear bigger (Matthews & Mackintosh, 2004), closer (Cole et al., 2013), and faster (Witt & Sugovic, 2012) than participants who reported lower levels of fear.

Although literature in this area has suggested fear to influence perception, alternate explanations for the results of this study should be explored. The correlations between mean error distance scores and participant fear ratings indicated that although the mechanisms behind the changes in distance perception due to mask wearing could be due to fear, fear was not significantly related to these scores. Thus, it should be explored that other possibilities, such as the simple presence of a mask acting as a perception beacon, could account for these perception changes. The simple presence of stimuli on the face could have generally influenced the distance that participants perceived the character at. Alternatively, the current fear measure may have not measured the specific type of fear that was experienced by participants in this study. Further studies utilizing additional control conditions (such as characters with other stimuli on the face) should be conducted to distinguish between these possibilities.

Fear and distance perception have also been studied in the context of proxemics. A primary theory within this area is the compensation, balance, and privacy theory of proxemics (McCall, 2016), which highlights the behavior of individuals to try and overcome violations of their personal space. These individuals try and maintain a level of comfort or equilibrium in situations that are considered to be “violating” in nature (Baldassare, 1978). Participants in the current study may have been motivated to adjust their distance perception based on the “violating” nature maintained during the pandemic (i.e., wearing masks creates an overall boundary of safety in society that is considered to be infringing when crossed). Virtual characters who were depicted as not wearing a mask may have been interpreted by participants as a violation in their environment, and therefore considered to be a violation to the safety boundary of individuals overall. Thus, a desire to return to the “safe” or “comfortable” environment previously known to participants (that is endorsed by wearing a mask) may have driven their changes in distance estimates. This may help to explain the results of the current study, indicating that virtual characters portrayed without a mask were perceived as being closer than those portrayed with a mask. If participants were not aware of a violation in their environment and were not motivated to adjust to this violation, error difference scores between these conditions may not have been as evident (i.e., there would not have been significant error differences noted between masked and non-masked conditions). As a result of participants endorsing underestimations for the non-masked condition, this supports participant knowledge of this overall “boundary” and supports that they perceived a violation or threat to it. This perception therefore resulted in higher error scores for the non-masked condition compared to the masked condition.

A recent study conducted by Cartaud, Quesque, and Coello (2020) has reported the opposite effect compared to my study, with shorter interpersonal distances being perceived for individuals pictured as wearing a mask compared to those who were not. There are several reasons why this may have occurred. First, this study was conducted within the context of emotional facial expressions (i.e., happy, angry, and neutral) and mask wearing. The use of emotion as an additional stimulus may have affected participant perception as this was not a component that was accounted for in my study. For example, the use of positive emotion expressed by the face may have inhibited threat perceived by the individual. Second, Cartaud et al (2020) used stimuli that were human-like and only depicted these stimuli from the waist-up. These discrepancies may have influenced distance estimates as the stimuli used were not the same (e.g., my study showed the whole body of the virtual character whereas their study only showed the top third). My study specifically focused on basic distance perception using familiarity and fear factors, with no emotions or other stimuli considered. The simple manipulation of mask presence/absence and presentation of the figure may have aided in tapping into the basic fear present in a pandemic scenario without potentially distracting factors such as emotion. Further research into the factors influencing this mechanism should be investigated to further understand its influence on distance perception. Additionally, further research should compare the influence of human and non-human-like stimuli and its relationship with distance perception when wearing a mask.

Contrary to my hypothesis, familiarity did not alter participant distance perception. Previous research suggests that the presence of out-group members decreases the amount of perceived distance between that member and a person of the in-group (i.e., they are perceived as being closer; Xiao & Bavel, 2012). This research suggests a fear component that influences this perception, perhaps tapping into the biological threat mechanism in humans. Within the context of the coronavirus pandemic, individuals are encouraged to wear masks to help prevent the spread of the disease. Individuals who are strangers may also present a feeling of threat, as these individuals are unknown and their level of possible threat is, in turn, unknown. When viewing others, these members of the in-group (i.e., friend group) may view those who they do not know as members of the out-group (i.e., stranger group). This hypothesis would align with Xiao and Bavel's findings, in which out-group members are perceived as being physically closer than in-group members. In my study, this effect was not supported. This may have occurred based on the scenarios (brief statements) that were presented in the second experiment describing a stranger or a friend. These scenarios may not have been long or strong enough to generate the feeling of familiarity needed. Thus, the results obtained may not accurately portray the role that familiarity plays in distance perception. Further studies should be conducted with more effective manipulations to induce a feeling of familiarity/unfamiliarity with the virtual character (e.g., using pictures of real friends).

When considering the correlations, participant fear ratings were found to be marginally correlated with age. This non-significant relationship was negative, thus indicating a trend that as participant ages increased, their fear ratings decreased. This was somewhat surprising as older individuals are considered to be a “vulnerable” population during the pandemic. Conversely, older individuals may be more knowledgeable about prevention of disease since their exposure to the flu and other viruses increases with age. Thus, this increase in knowledge may help explain why their fear scores were marginally negatively correlated.

Other relationships between variables were not found. A plausible reason could be that the fear responses indicated by participants in the survey may not be related to the fear they experienced while completing the experimental tasks. Considering this experiment was virtual in nature, participants may not have experienced the same level of fear that they would have if faced with an actual person in real life. Additional studies assessing the role of perceived fear in both virtual and real-life settings should be explored to indicate whether this finding is common or a result of the current study methods.

Limitations

There are several limitations to the study that need to be addressed. First, the virtual task that was utilized in this experiment has not been previously compared to real world distance estimations. The use of a virtual environment can provide many advantages such as ease of access to participants and control over extraneous variables, but it is important to note that the results of the study should be interpreted cautiously. Although the results of my study indicate an effect of mask wearing, participants, when encountered with human beings in a natural setting, may experience the effect of masks differently. Virtual stimuli may not simulate the presence of an actual human being in a real-world setting, especially because in a virtual task, participants know they are not at risk of being infected. Thus, additional studies should be conducted to examine this phenomenon using actual individuals as stimuli.

Furthermore, several constraints to the diversity of the sample of participants should be noted. This study's participant pool consisted largely of Caucasian, female individuals. A lack of diversity in race and gender constricted my ability to analyze these factors and inhibited my ability to generalize the findings to other groups. It may be possible that other races and genders, perhaps those who are at a higher risk of developing disease, including coronavirus (such as African Americans; John Hopkins Research Center, 2021), may interpret the distances of these characters differently. Additionally, the recruitment sites that were used in the study should be expanded to include individuals who may not use social media or have access to internet resources. Thus, additional research should be conducted that includes other demographic groups to better assess whether these results generalize to these populations and to gain insight into distance perception in these groups as well.

Several recommendations for future research objectives have been mentioned previously. It would be beneficial to start by conducting an equivalent experiment but in a natural setting with actual humans. It would be advantageous to understand the influence of masks as it pertains to actual human interaction before further investigating the other effects that mask wearing may have on perception. This may be conducted analogously, by simply using photos of real individuals at the various distances instead of the virtual characters. This would allow for a better examination of the real-world phenomenon while still keeping the same control over extraneous variables and having an ease of access to participants. Several studies within perception literature have included other factors (such as emotion and facial expression) and implementing these factors may be beneficial in future research as it allows for more facets of human interaction to be accounted for. Further, a greater generalizability to clinically relevant populations should be aimed for as well in these studies. The present study allowed for simple systematic investigation of the impact of two specific variables (mask-wearing and familiarity) on distance perception, but additional variables should be addressed as well as perception is made up of a variety of factors that occur simultaneously. Thus, further research should strive to encompass these factors to provide the most accurate assessment of perception.

Conclusion

This study addressed the role of masks and familiarity in distance perception. Using a novel virtual experimental task, I found that mask-wearing does impact distance perception, suggesting that the role of fear may be implicated in closer distance estimates of non-masked virtual characters. Generally, the Coronavirus pandemic has led to an increased focus on the distance of others from ourselves, with the CDC recommending that individuals maintain a six-foot distance away from each other. My results highlight the importance of recognizing factors that may impede accurate distance judgment and following of these guidelines. The findings suggest that the simple presence or absence of masks on a virtual person does, in fact, alter distance perception. Additional studies should be conducted to determine the accuracy of these effects in real-life settings. Further research should also work to identify other factors that impact perception in life-threatening situations, such as a global pandemic. Increased understanding of these factors may prove to have clinical importance as we can begin to educate individuals about lapses in perception that can implicate their health and safety as well as begin to develop methods to negate these factors.

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Table 1

Table of Correlations for Demographic Variables and Fear Ratings with Mean Error Scores.

Variable	**Age**	**Education**	**Fear Ratings (TS)**
Age	-	.078	-.219 †
Education	.078	-	.017
Fear Ratings (TS)	-	-	-
Ex1: (M)	.005	.046	-.035
Ex1: (NM)	.078	-.085	-.117
Ex2: Friend (M)	-.093	.044	.060
Ex2: Friend (NM)	-.079	-.010	.040
Ex2: Stranger (M)	.034	.053	.118
Ex2: Stranger (NM)	.016	.054	.047

Note. Fear ratings (6 items) were summed to create a total score (TS). This score was used to correlate to the main variables. "M" indicated masked condition error scores and "NM" indicates non-masked error scores.

Significance ($p < .05$) is indicated by an asterisk (*). Marginal significance ($p < .07$) is indicated by an obelisk (†).

Figure 1

Changes in Participant Distance Error as a Function of Mask-Wearing

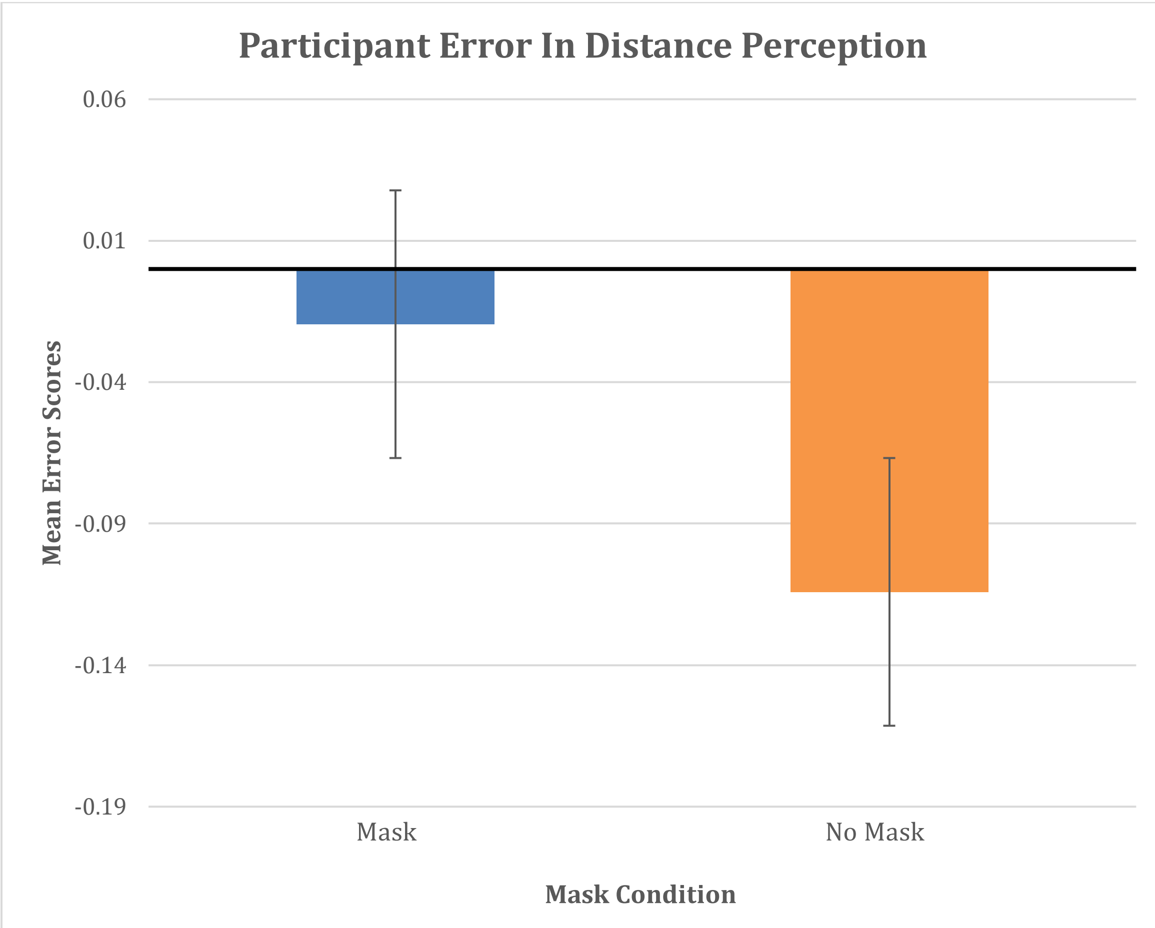


Figure 4. Participant mean distance error scores in both masked and non-masked conditions are presented for Experiment 1 (+ SEM). These scores indicate that participants underestimated virtual character distances at a higher amount in trials where masks were not depicted compared to trials where masks were depicted. This difference was statistically significant.

A mean error score of zero indicates an absence of bias in participant error scores.

Figure 2

Changes in Participant Distance Error as a Function of Mask-Wearing and Familiarity

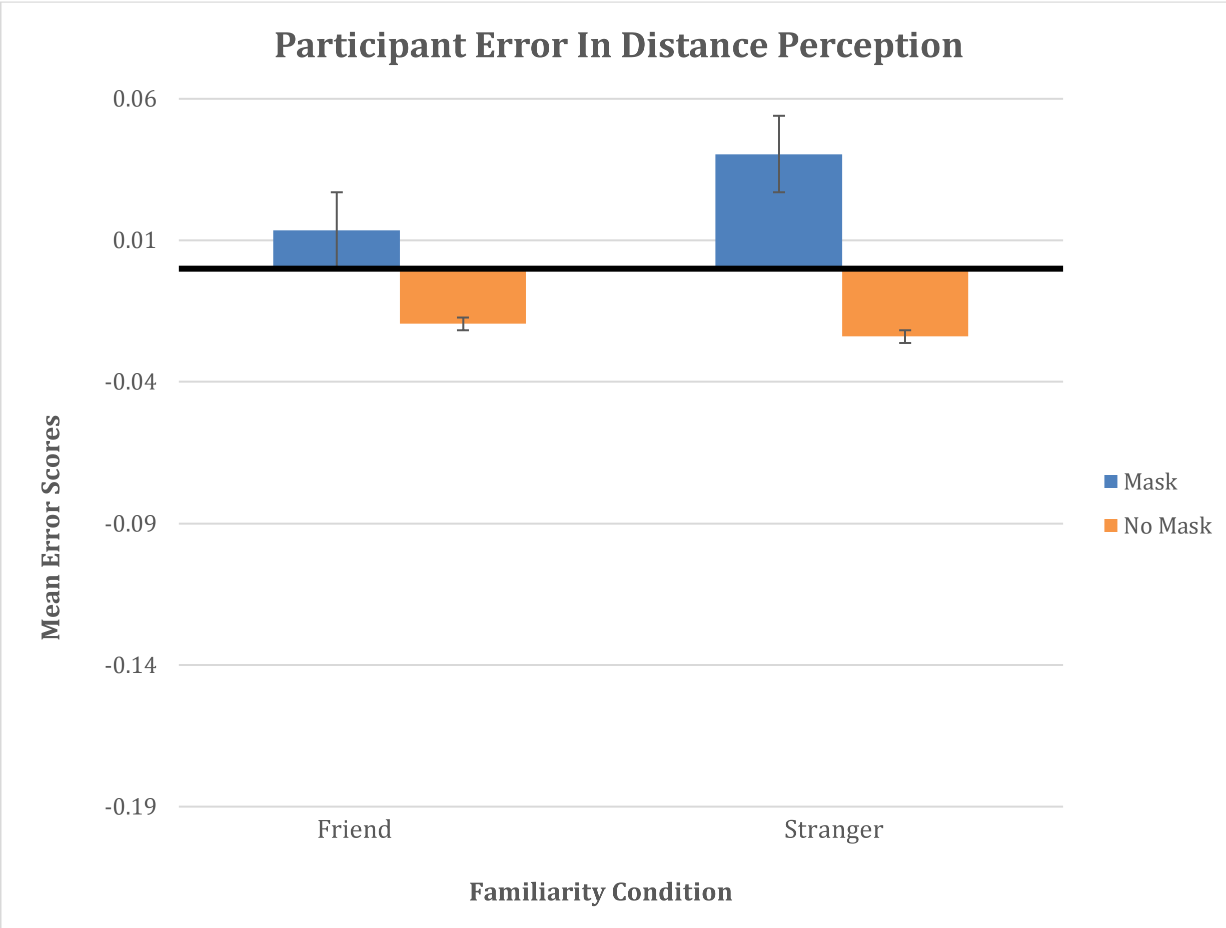


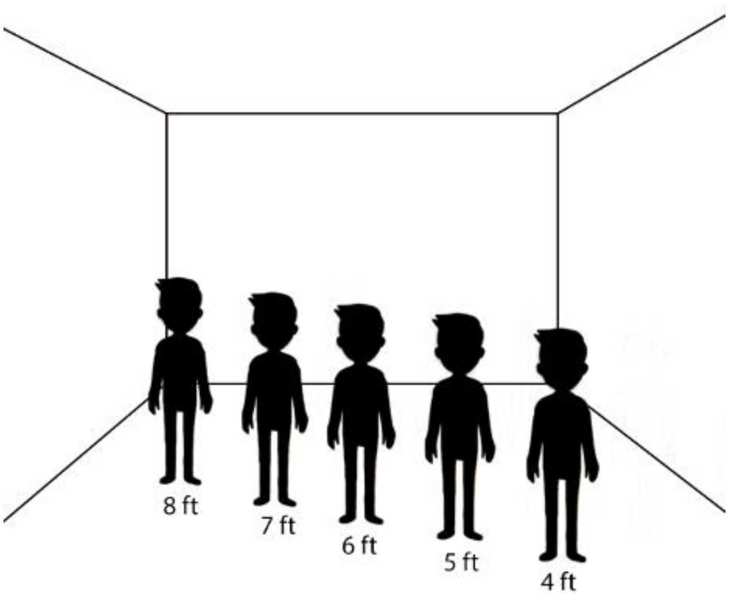
Figure 5. Participant mean distance error scores are presented for Experiment 2, broken down by familiarity factor (friend or stranger) and mask wearing factor (mask presence or absence). There was a significant effect of mask wearing, indicating participants underestimated virtual character distances in trials where masks were not depicted. The effect of familiarity and the interaction were not significant.

A mean error score of zero indicates an absence of bias in participant error scores.

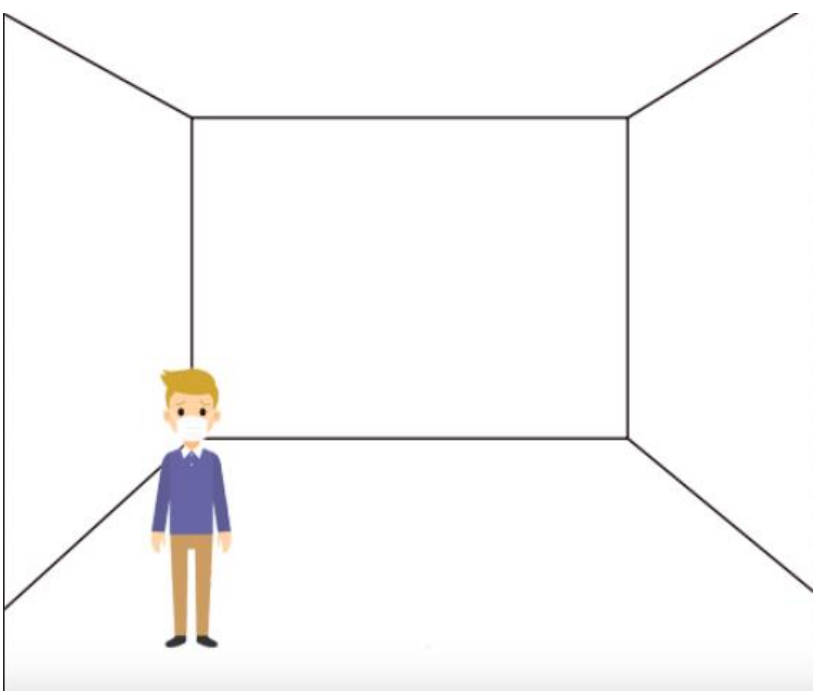
Appendix A

Examples of Stimuli in Each Experimental Condition

Experiment 1: Mask Condition

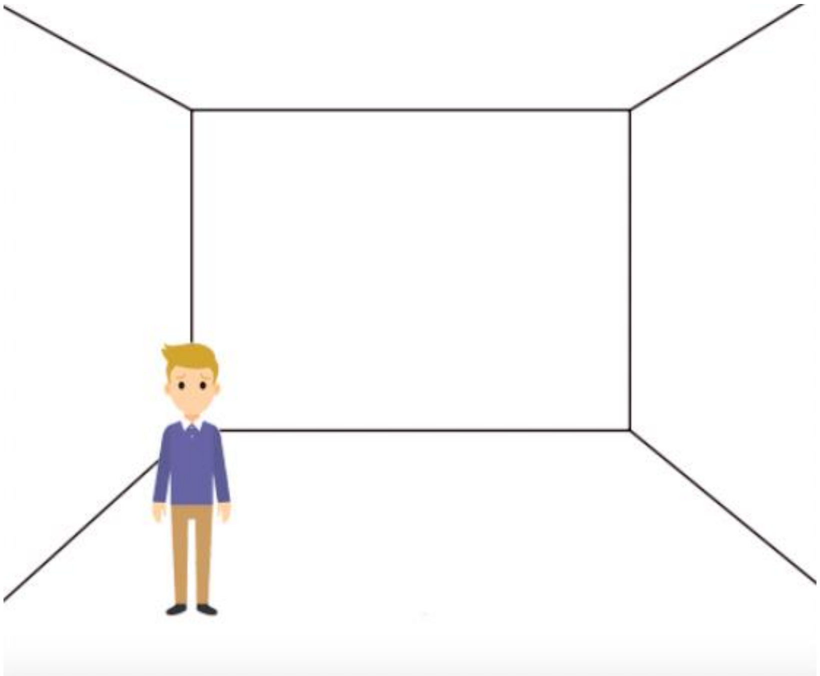


Note. *Distance image for participants to study at beginning of each experimental trial.*



How far away is Joe?
8ft 7ft 6ft 5ft 4ft

Note. Sample masked trial for experiment 1. Character is depicted at a 4-foot distance.

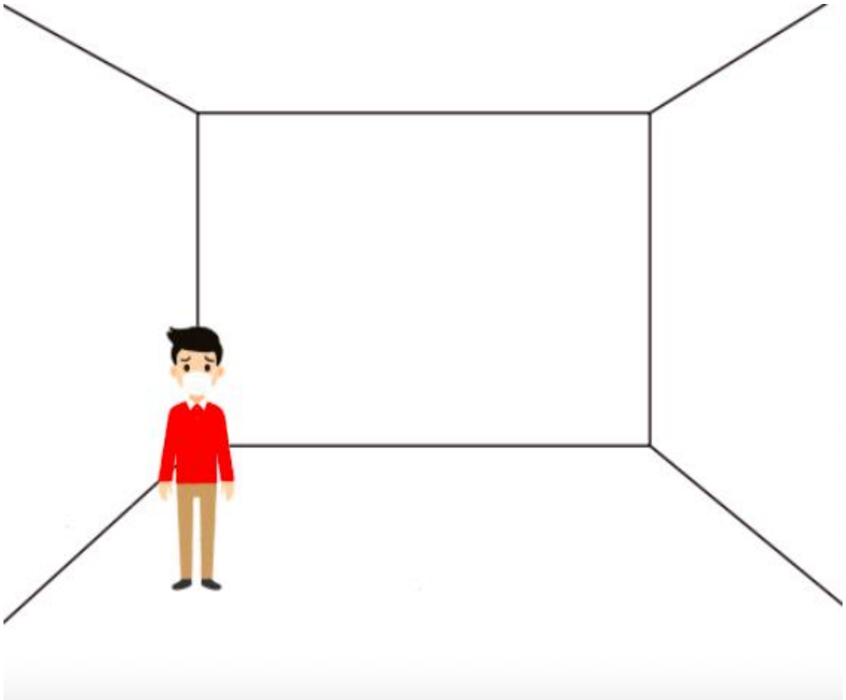


How far away is Joe?
8ft 7ft 6ft 5ft 4ft

Note. Sample non-masked trial for experiment 1. Character is depicted at a 5-foot distance.

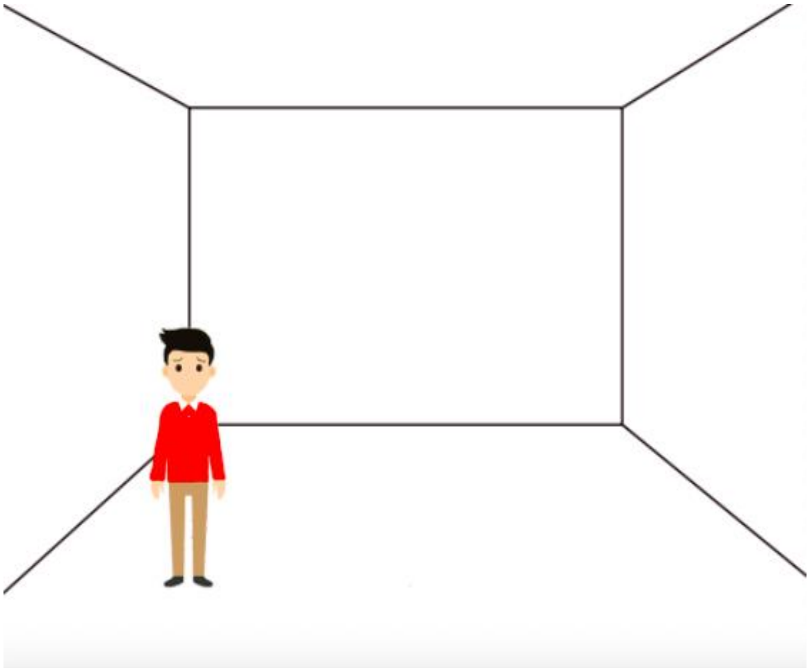
Experiment 2: Familiarity Condition

"Friend" Scenario: "You are walking in the park and stop to watch a squirrel eat a nut. A person approaches you, and when you look up, you see it is your friend Fred. You stop to talk with Fred, and he informs you that he recently received a promotion. You congratulate him and agree to celebrate with dinner and drinks later that day."



How far away is Fred?
8ft 7ft 6ft 5ft 4ft

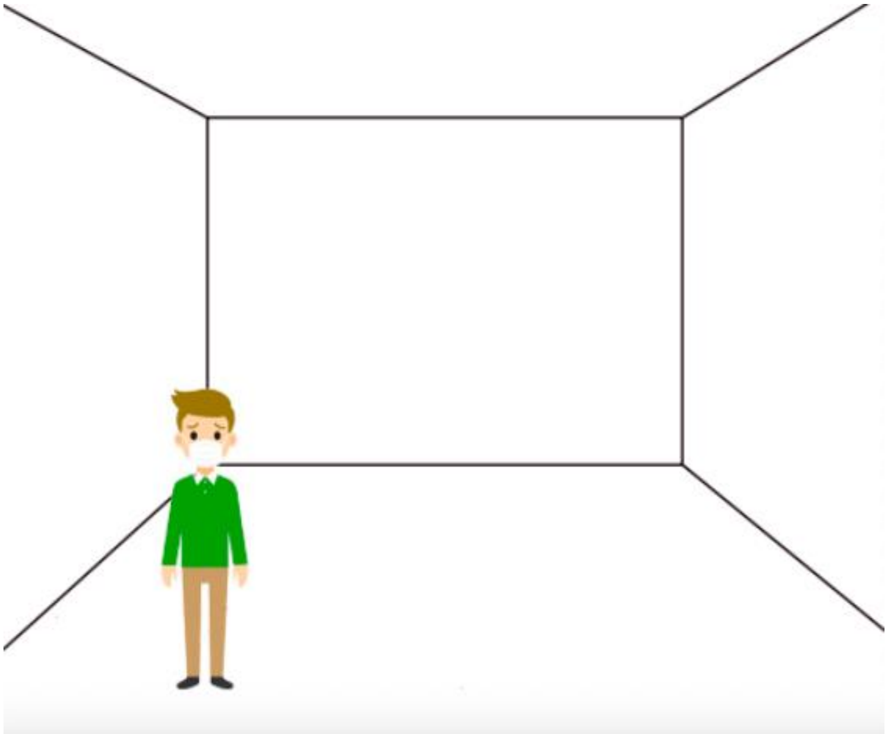
Note. *Sample trial for masked, "friend" condition in experiment 2. Character is depicted at 8-foot distance.*



How far away is Fred?
8ft 7ft 6ft 5ft 4ft

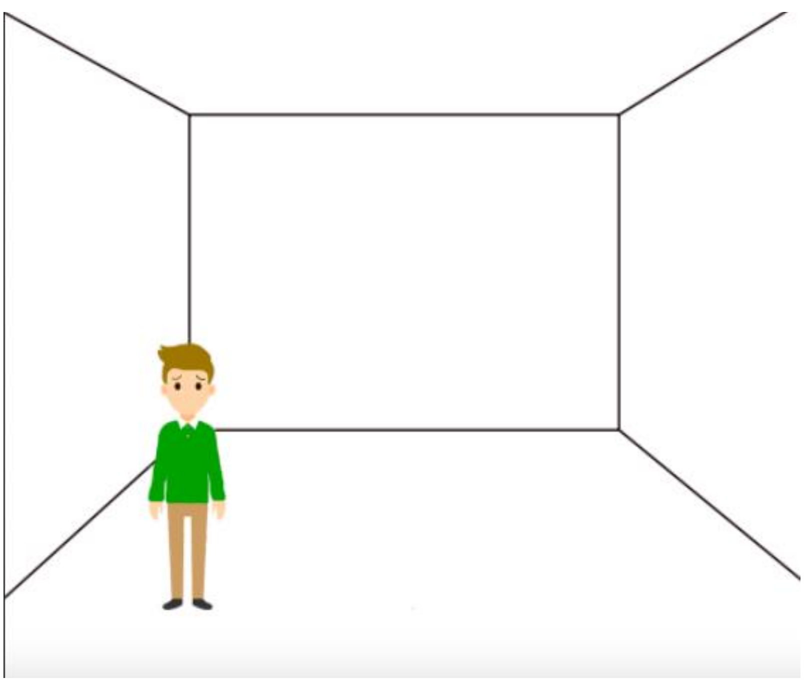
Note. *Sample trial for non-masked, "friend" condition in experiment 2. Character is depicted at 7-foot distance.*

"Stranger" Scenario: "You are walking to your car and notice someone is getting out of the car parked next to you. He seems to be in a rush and slams his door loudly, making you jump. You do not recognize this person."



How far away is Clyde?
8ft 7ft 6ft 5ft 4ft

Note. Sample trial for masked, "Stranger" condition in experiment 2. Character depicted at 4-foot distance.



How far away is Clyde?
8ft 7ft 6ft 5ft 4ft

Note. *Sample trial for non-masked, "Stranger" condition in experiment 2. Character depicted at 5-foot distance.*

Appendix B

Follow Up Survey

1. What is your age (ex: 18)?

2. What is your sex?
   a. Male
   b. Female
   c. Non-binary
   d. Prefer not to answer

3. What is your ethnicity?
   a. Caucasian
   b. African American
   c. Asian
   d. Latino or Hispanic
   e. Native American
   f. Native Hawaiian or Pacific Islander
   g. Multiracial
   h. Other (Please enter below)
   i. Prefer not to say

4. What is the highest degree or level of education you have completed?
   a. Some high school
   b. High school
   c. Some College
   d. Associate’s Degree
   e. Bachelor’s Degree
   f. Master’s Degree
   g. PhD or higher

h. Trade School
i. Prefer not to say

Please rate the level to which you agree with the following statements:

1. I feel comfortable being close to an individual in public during the coronavirus pandemic.

(1) Strongly Disagree	(2) Agree	(3) Neither Agree Nor Disagree	(4) Disagree	(5) Strongly Agree

2. I feel comfortable being close to an individual in public <u>without a mask</u> during the coronavirus pandemic.

(1) Strongly Disagree	(2) Agree	(3) Neither Agree Nor Disagree	(4) Disagree	(5) Strongly Agree

3. I feel comfortable being close to an individual in public <u>with a mask</u> during the coronavirus pandemic.

(1) Strongly Disagree	(2) Agree	(3) Neither Agree Nor Disagree	(4) Disagree	(5) Strongly Agree

4. I feel comfortable being in public <u>without a mask</u>.

(1) Strongly Disagree	(2) Agree	(3) Neither Agree Nor Disagree	(4) Disagree	(5) Strongly Agree

5. I feel comfortable being in public <u>with a mask</u>.

(1) Strongly Disagree	(2) Agree	(3) Neither Agree Nor	(4) Disagree	(5) Strongly Agree

		Disagree		

6. I am fearful of the coronavirus and the coronavirus pandemic.

(1) Strongly Disagree	(2) Agree	(3) Neither Agree Nor Disagree	(4) Disagree	(5) Strongly Agree

7. I am not fearful of the coronavirus and the coronavirus pandemic.

(1) Strongly Disagree	(2) Agree	(3) Neither Agree Nor Disagree	(4) Disagree	(5) Strongly Agree

Appendix C

Task Instructions

Silhouette Image:

Please study the image below. When you have become familiar with the distance estimates, please click the arrow below to begin the task.

Experiment 1:

You will view a series of images in which a virtual character will be depicted either wearing or not wearing a mask. Please choose the corresponding distance of the virtual character from the answers listed below. **You will be given <u>10 seconds</u> to give your distance estimate for each trial.** If you do not know the distance, please give your best estimate.

Experiment 2:

You will be given a short scenario followed by a series of images. These images contain a virtual character either wearing or not wearing a mask. Please read through the scenario and choose the corresponding distance of the virtual character from the answers listed below. **You will be given <u>10 seconds</u> to give your distance estimate for each trial.** If you do not know the distance, please give your best estimate.